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Seismic Analysis of Irregular Multistorey Building

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Abstract: The seismic analysis of buildings is crucial for ensuring structural safety and resilience against earthquake forces. Irregularities in building configurations pose unique challenges, influencing the distribution of seismic forces throughout the structure. This study focuses on the seismic analysis of a G+12 building characterized by irregularities in plan and elevation using STAAD.Pro software. Here we have taken four models consisting of bare bay frame , bay frame with shear wall on one corner, , bay frame with shear wall on two opposite corners, , bay frame with shear wall on all corners for the further analysis. This research contributes to enhancing understanding and design practices for irregular high-rise buildings, emphasizing the importance of advanced analytical tools in seismic engineering. From this analysis we can conclude that within all four models ,building having shear wall on all four sides shows minimal deflection attributed to its maximum stiffness characteristics, hence considered most stable.
Keywords: Irregularities, Shear wall, Static analysis, Response spectrum ,Time history.

I. INTRODUCTION

The structural integrity of high-rise buildings during seismic events is critical for ensuring public safety and minimizing economic losses. Irregularities in building geometry and structural configuration can significantly influence seismic vulnerability and require careful analysis and design considerations. Findings from the analysis of irregular buildings contribute to the development and refinement of building codes and standards. This ensures that structures are designed and constructed to withstand seismic forces effectively, enhancing public safety.

Knowledge of how irregular buildings respond to seismic forces contributes to disaster preparedness efforts. It allows authorities to develop emergency response plans and evacuation strategies tailored to specific building types, ultimately saving lives during earthquakes.

II. METHODOLOGY

This study employs a linear static approach using STAAD.Pro software to model and simulate the structural behavior of the G+12 irregular building under seismic loading. The methodology includes:

- Building geometry and structural details
- Material properties and seismic design parameters
- Application of ground motion records as per seismic hazard analysis
- Analysis of seismic response including modal analysis, dynamic time history analysis, and response spectrum analysis.

The four models are as follows:

- MODEL 1: Bay frame with no shear wall.
- MODEL 2: Bay frame with shear wall placed at one corner.
- MODEL3: Bay frame with shear wall placed at two corners.
- MODEL4: Bay frame with shear wall placed at all corners.

TABLE .1 : Bay frame with no shear wall

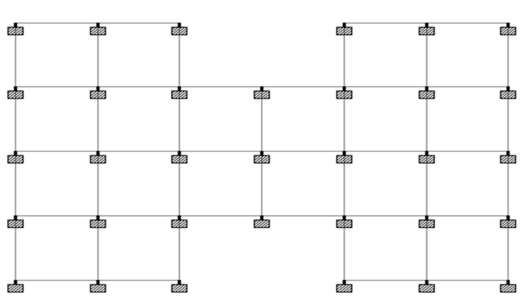


Fig 1PLAN VIEW OF MODEL 1

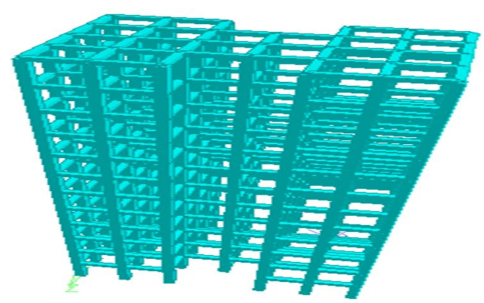
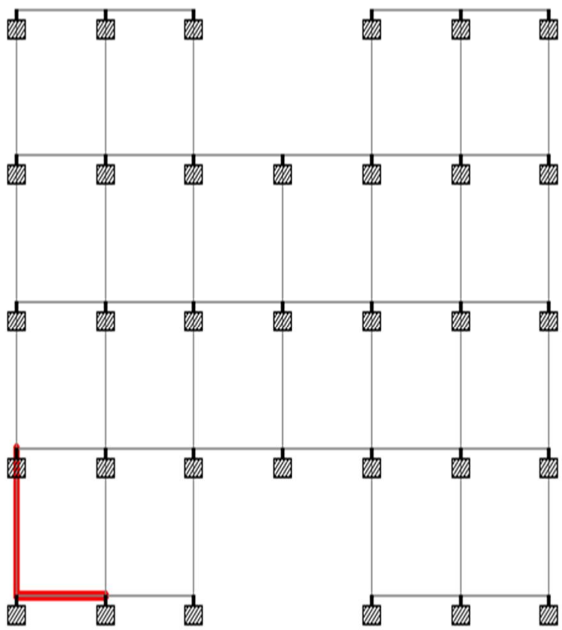


Fig.2 3D RENDERING VIEW OF MODEL 1



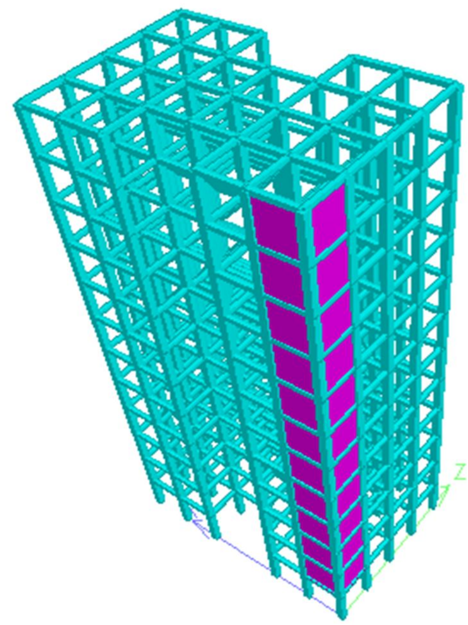
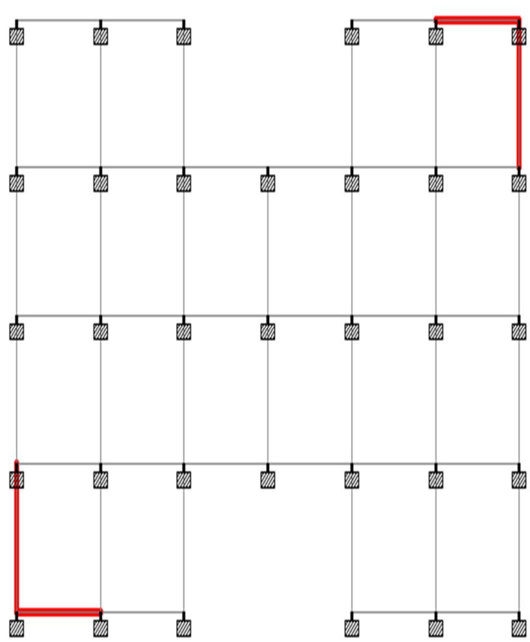


Fig .3 PLAN VIEW OF MODEL 2

Fig .4 3D RENDERING VIEW OF MODEL 2

TABLE 2 .: Bay frame with shear wall placed at one corner



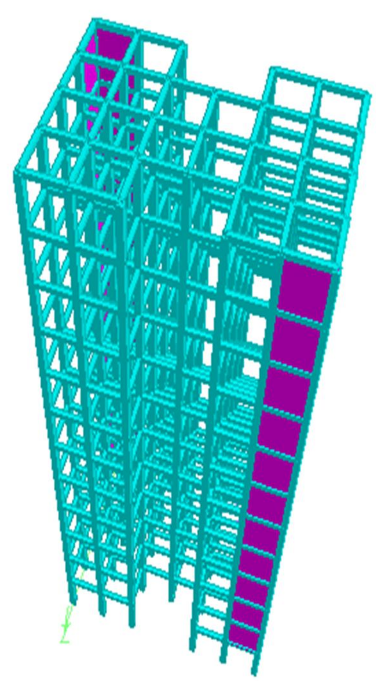


Fig 5 PLAN VIEW OF MODEL 3

Fig .6 3D RENDERING VIEW OF MODEL 3

TABLE 3 : Bay frame with shear wall placed at two corners

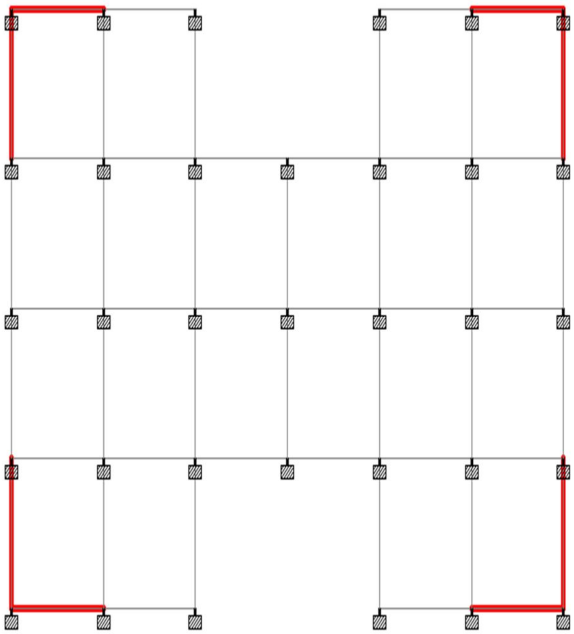


Fig 7 PLAN VIEW OF MODEL 4

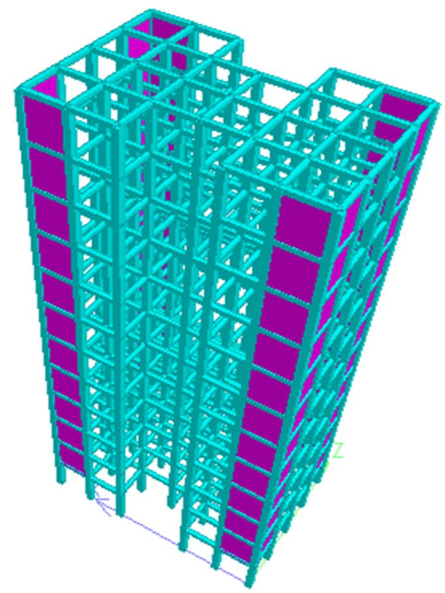


Fig .8 3D RENDERING VIEW OF MODEL 4

TABLE .4 : Bay frame with shear wall placed at all corners

LOADS

The loads combination that are considered according to the IS 1893-2002(Part -1) for the seismic analysis of the structure are:

- 1.5 [DL+ LL]
- 1.2[DL+ LL+EQX]
- 1.2[DL+LL- EQX]
- 1.2[DL+ LL+EQZ]
- 1.2[DL+LL- EQZ]
- 1.5[DL+EQX]
- 1.5[DL- EQX]
- 1.5[DL+EQZ]
- 1.5[DL- EQZ]

III. RESULTS

The seismic analysis results are presented and discussed, focusing on:

1) Natural frequencies and mode shapes
2) Seismic forces and distribution of internal forces
3) Displacement patterns and deformation characteristics
4) Performance evaluation based on seismic performance criteria (e.g., drift limits, capacity checks)
5) The result is based on the seismic motion response of bay frame model in static and dynamic responses .The response changes in prototype and different placements of shear wall are plotted. The result includes base shear, top storey drift , top storey displacement and storey shear for ground seismic motion along X direction and Z direction in both static and dynamic response spectrum method are considered for all four models. These results are then plotted and compared with each other and then concluded.
6) In time history analysis the data of various earthquakes in Indian history are collected from virtual data center and scaled down to seismic peak acceleration value for zone IV (as defined in IS 1893-2002(part-1)) i.e. 0.24, and velocity –time graph is plotted for four different earthquake data to all four models and compared for peak values in x- direction.

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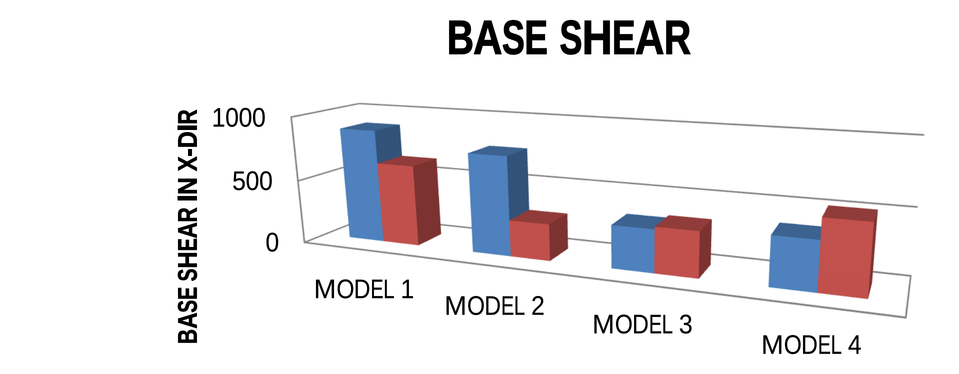
IV. COMPARISION OF RESULTS FOR EQUIVALENT STATIC AND RESPONSE SPECTRUM ANALYSIS

1) Comparision Of Base Shear

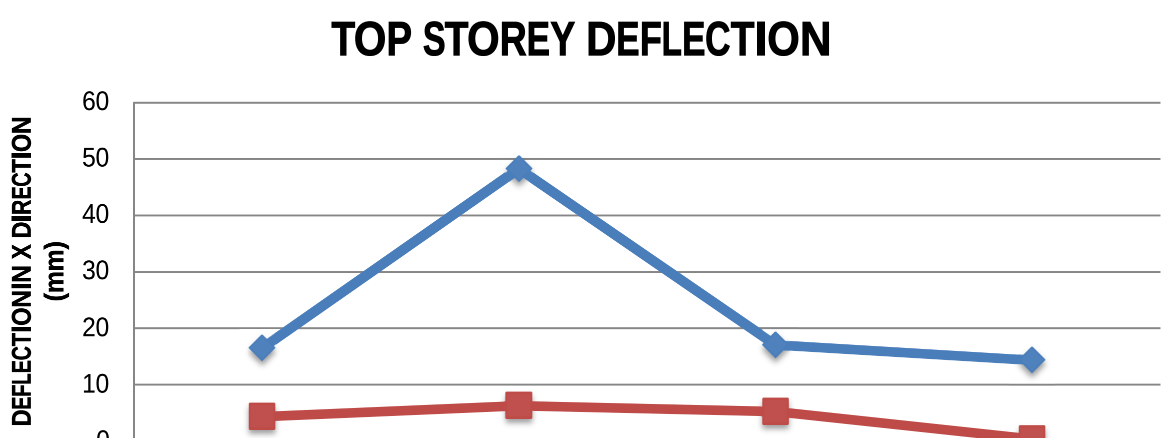


	MODEL 1	MODEL 2	MODEL 3	MODEL 4
EQX	887.181	766.921	325.045	367.162
RSX	631.64	280.8	344.27	520.45

Fig .9 Variation of base shear for seismic force in x- direction

The base shear in models are found to be in decreasing order from the prototype model to the shear wall frame models in static analysis and seems to be increasing between shear frame models in dynamic analysis..The base shear is maximum in model 1 in both static and response spectrum analysis, and the minimum value in model 3 in both cases in x- direction. The model 3 was found to be having very less difference in their values for both analysis cases.

2) Comparision Of Top Storey Deflection



	MODEL 1	MODEL 2	MODEL 3	MODEL 4
EQX	16.5	48.3	17.1	14.4
RSX	4.3876	6.2454	5.2542	0.4522

Fig .10. Variation in Top Storey Deflection for seismic force in x-direction

From the data, the top storey deflection appears that the EQX model generally has higher deflection values compared to the RSX model. This suggests that, on average, the EQX model exhibits more deflection at the top story compared to the RSX model. The model 2 seems to give a large deflection due to its concentrated mass at a corner (mass irregularity) present in the structure. Whereas the model 4 produces least deflection in all type of structure considering maximum stiffness.

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3) Comparision Of Storey Shear

The term "storey shear" refers to the shear force experienced at each level or storey of a building or structure. Shear force is a type of internal force that acts parallel to the cross-section of a structural element, causing it to deform or shear. In the context of a multi-storey building, storey shear specifically refers to the shear force experienced at each floor level.

Patterns in the shear values across storeys can provide insights into the overall behaviour of the building under lateral loads. For example, consistent increases or decreases in shear from the base to the top storeys may indicate specific structural characteristics or design features. Generally, as we move up the storeys, the shear force may fluctuate. However, there might be an overall decreasing or increasing trend depending on the building's design and the distribution of loads. We can observe that the shear values fluctuate across the storeys for each model. MODEL 1 consistently exhibits the highest shear values across all storeys, followed by MODEL 4, then MODEL 3, and finally MODEL 2 with the lowest shear.

Following fig. shows the graphical representation of the variation in storey shear due to seismic load in all models.

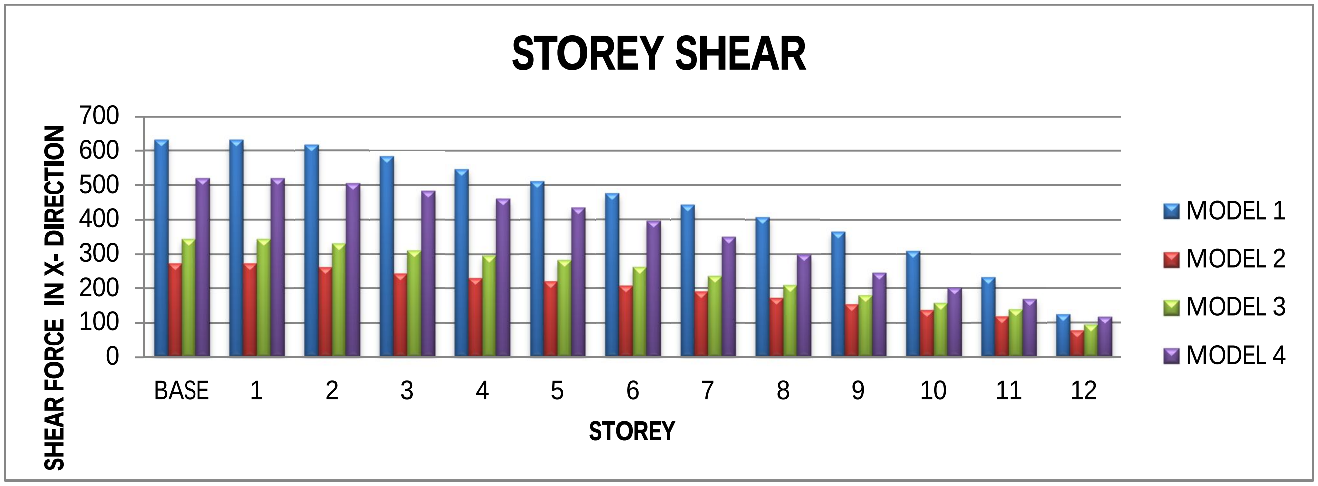
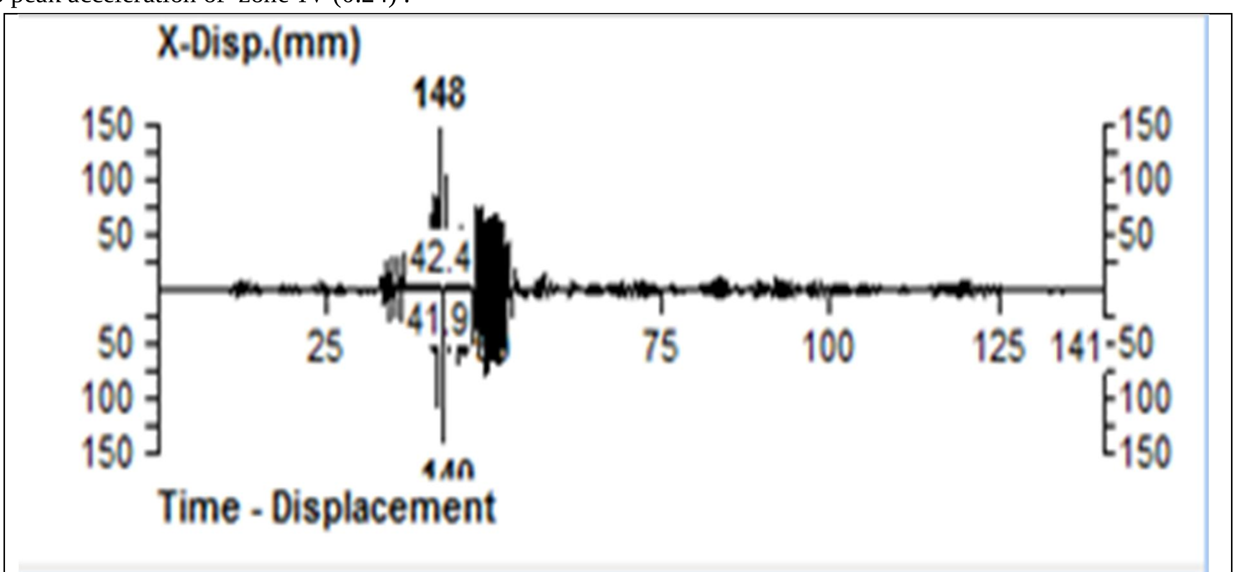


Fig .11. Variation of Storey Shear in x- direction

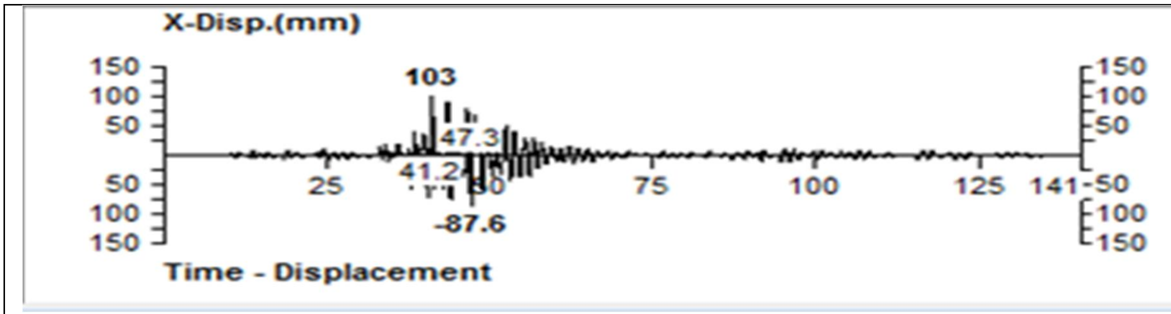
V. TIME HISTORY ANALYSIS

1) Comparision Of Peak Ground Motion Of Type 1 Acceleration(EQDATA)

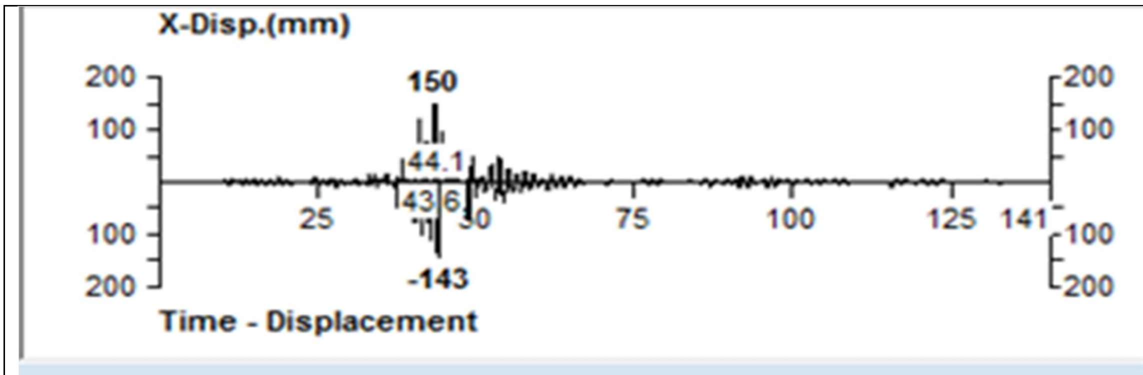
Following table shows the output response of time history analysis for TYPE-1.These result shows peak value of the time –displacement relation in x-direction. The type-1 acceleration is taken from the values of "Bhuj" seismic acceleration which is scaled to peak acceleration of zone-IV (0.24) .



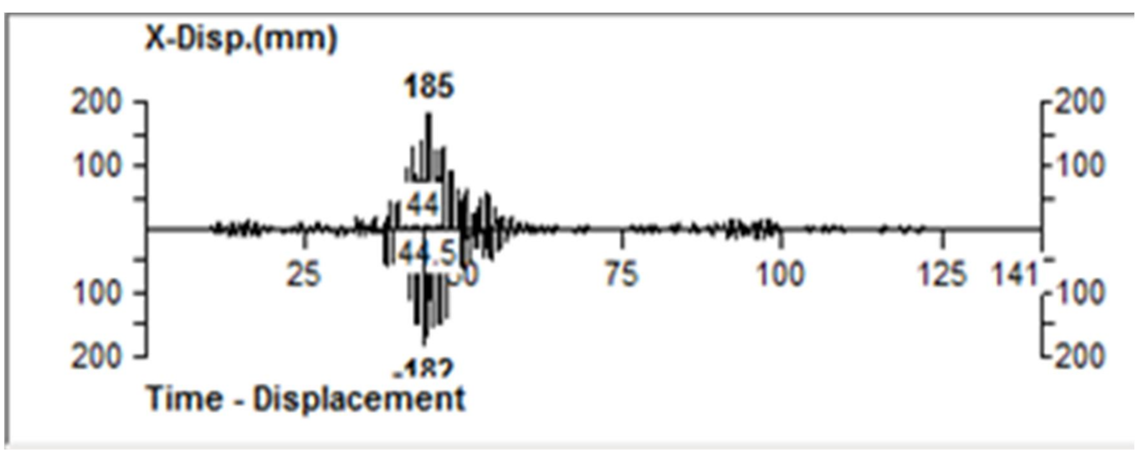
MODEL 1



MODEL 2



MODEL 3



MODEL 4

TABLE.7. Peak Displacement in –direction due to TYPE -1 Acceleration

From table 7 , it is speculated that Model 4 shows maximum displacement compared to other models, and Model 2 shows least displacement values for the same acceleration.

Following are the graphical representation of peak ground motion data of different earthquake sites such as Eqadata1 represents the type-1 acceleration is taken from the values of "Bhuj" seismic acceleration which is scaled to peak acceleration of zone-IV (0.24) , Eqdata 2 represents the type-2 acceleration is taken from the values of "Indo-Burma" seismic acceleration which is scaled to peak acceleration of zone-IV (0.24), Eqadata3 represents the type-3 acceleration is taken from the values of "Chamoli" seismic acceleration which is scaled to peak acceleration of zone-IV (0.24), Eqadata4 represents the type-4 acceleration is taken from the values of "Uttarkashi" seismic acceleration which is scaled to peak acceleration of zone-IV (0.24)

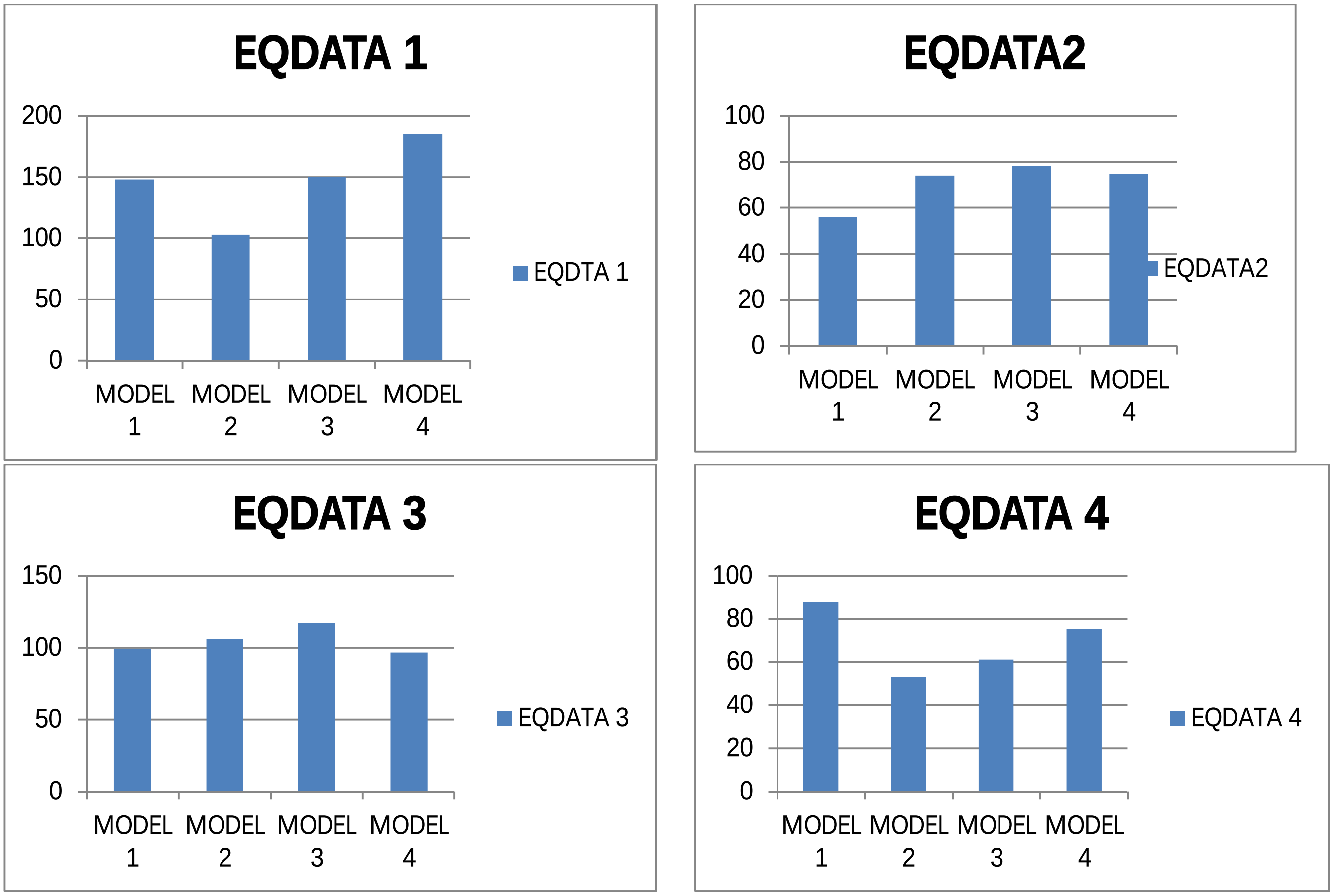


Table. 8 Graphical representation of peak ground motion .

VI. DISCUSSION

The findings are interpreted to assess the building's seismic vulnerability and performance under various earthquake scenarios. Key factors influencing the structural response, such as irregularities in plan and elevation, are analyzed. Comparison with relevant design codes and standards is also discussed.

VII. CONCLUSION

In conclusion, the seismic analysis using STAAD.Pro software provides valuable insights into the behavior of the G+12 irregular building under seismic loading. Recommendations for structural enhancements and future research directions are outlined to improve seismic resilience in high-rise constructions.

1) The base shear is maximum in model with shear wall at two opposite corners in both static and response spectrum analysis, and the minimum value in model in both cases in x- direction and z-direction.
2) The model with shear wall at two opposite corners seems to give a large deflection due to its concentrated mass at a corner (mass irregularity) present in the structure. Whereas the model having shear wall on all corners produces least deflection in all type of structure considering maximum stiffness. Hence we can conclude that of all the types , building model having shear wall on all corners exhibits overall stable results.

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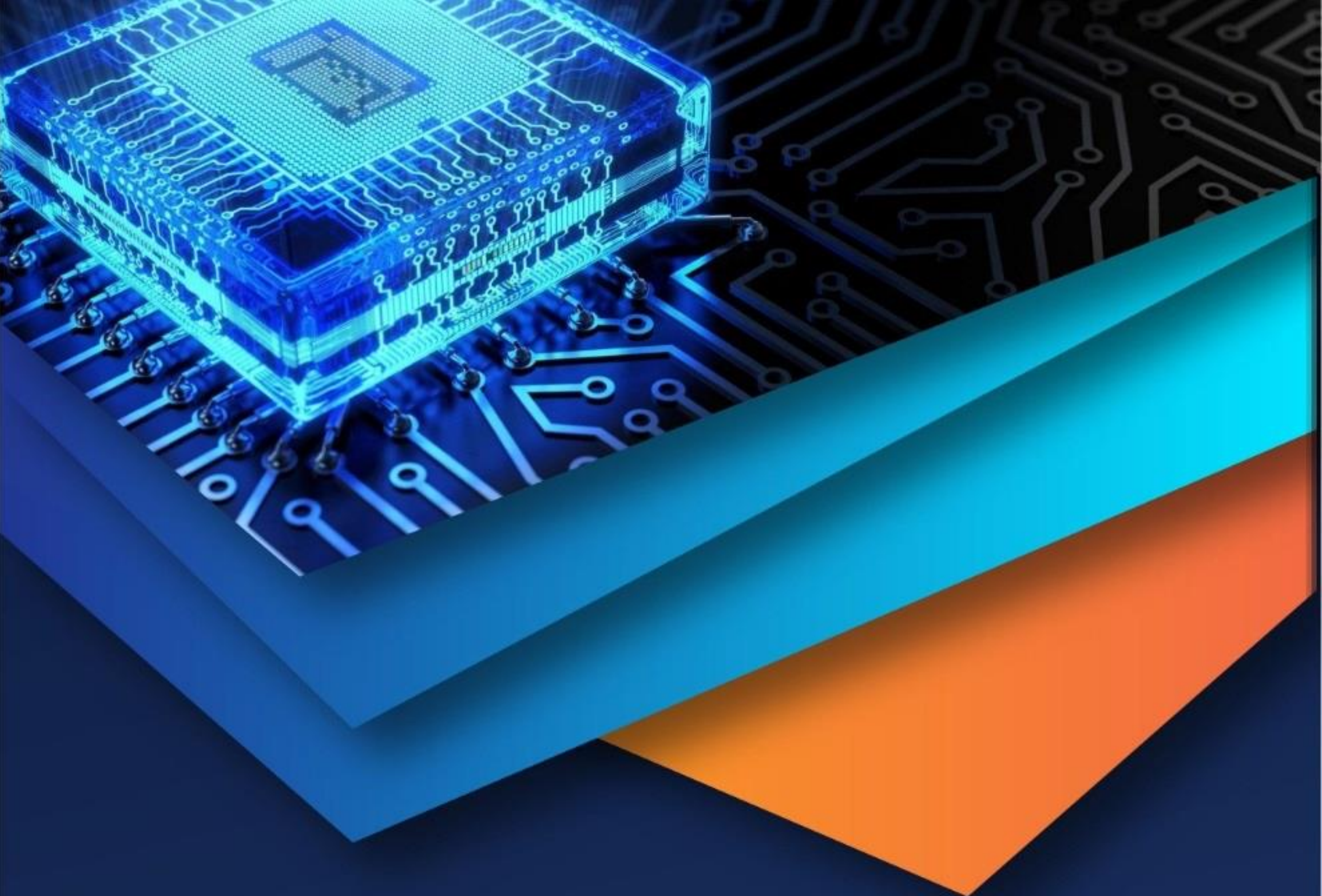

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